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ABSTRACT

This study investigated the possibility of creating a computer-assisted remediation program to assist students having difficulties in basic college research and statistics courses. A team approach involving instructors and students drove the research into and creation of the computer program. The effect of student use was reviewed by looking at the process using action research in a series of studies. The first pilot study investigated screen designs without in depth analysis. A second pilot study investigated the statistical portion of the presentation through the responses of 12 graduate students. Results were used in third pilot and fourth pilot studies in which static and animated graphics were studied using 40 graduate students. No significant differences were found between static and animated graphics. A fifth pilot measured individual differences with 75 undergraduates and suggested that a locus of control measure would be useful. Additional pilot studies investigated freedom of navigation through the program (50 graduate students) and presentation modes (103 graduate students). These results are being used in the development of a full semester computer-assisted course in introductory statistics. (Contains 17 references.) (SLD)

Action Research of Computer-Assisted-Remediation of Basic Research Concepts

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This study investigated the possibility of creating a computer-assisted remediation program to assist students who were having difficulties in basic research and statistics courses in pursuit of their college degree. A team approach consisting of a collaboration of instructors and students drove the research and creation of the computer program. There were several requirements believed important in this computer-assisted-instruction (CAI): flexibility to delivery multiple modes, quick content changes, and most importantly to have the ability to adjust to the individualistic traits of the participant.

The effect of student use was reviewed by looking at the process using action research. Action research as suggested by Lewin.(1976) was an process where the participants actively worked to change an existing environment to improve its effectiveness. In this study, students, faculty/designers worked together to create a computer-assisted learning environment. There are six steps while using action research: define the problem, select a design, select a sample, analyze the data, interpret and apply the findings and report the findings. This paper looks at the evolution of the development of a computer-assisted learning environment through several development stages.

Defining the problem

Many college students, especially those in the social sciences and humanities, have not chosen mathematics as a future direction in the life but yet find themselves required to take a course in statistics. Often these students have "math anxiety" which creates an negative atmosphere increasing the difficulty of learning statistics. While studying mathematics students, Genshaft (1982), stated that the cognitive processes related to mathematics anxiety were "particularly insidious" and this anxiety had "far reaching consequences." Other researchers have stated the negative effect anxiety places on learning mathematical and statistical skills (Knowles, 1994; Wolfe, 1978; Elmore, 1979; and Capps, 1983). It is appropriate to look for ways to reduce anxiety and fears associated with the study of statistics and to discover how a subject can be made more relevant in the student's perception. One such possibility resides in the use of computers as an aid to delivery of statistical instruction. In classrooms in which statistics are taught computers have been suggested as a solution to interact with students; they

serve as patient tutors and unbiased examiners, allowing the student freedom of pace and time (Kulik, 1980).

Selecting a design

In the past, one issue that has been continually debated (Clark, 1994; Kozma, 1994) in the development of Computer Assisted Instruction (CAI) programs was the lack of a theoretical base. This lead to the development of a CAI system based on the psychology of Egon Brunswik. Brunswik (1956) asserted that human behavior should be treated as probabilistic therefore he suggested a learning environment rather than a teaching environment. Reigeluth's study (1996) reinforced this stating that instruction should have "a focus on making sure that learners' needs are met -- a 'Learning-Focused' paradigm."

A Brunswikian learning environment was developed using nine components (Fortune, Packard, and Holmes, 1994). These components contain contemporary reforms such as self-pacing and feedback. The attempt was to form an environment based on a single, internally consistent theory where all components work together. Hence, one is not looking at the effects of a continuous progress curriculum, but a system designed to address the individual. The requirements were that the instructional material needed to be presented in a user friendly environment as well as having the capability to adjust for individualistic learning characteristics. An authoring program was used allowing the flexibility needed to present varying presentation modes: audio, textual, static or animated graphics, video and an interactive. To design and implement this study a audience and subject material had to be selected. All participants were students enrolled in the College of Education. The subject material was created to include some of the basic elements of research required for these individuals.

Creating system

The first study investigated various screen designs using the participant's feedback into the design process. These participants were drawn from a class in authoring program who were learning about the screen design and its importance. One early design attempted a lighthearted approach with a character of an old school teacher pointing to a blackboard fill with instructional material. This was found humorous by the students but soon became boring and was found to

interfere with the instructional material. Participant's feedback helped the development of a multi-windowed screen design allowing multiple mode delivery.

Three instructional strategies designed for delivery via a multimedia environment and piloted for this study; that is, simulation (text, graphics and animated interaction) programmed instruction (text, graphics, and non-animated interactions) and taped lecture (text, video vignettes and no interaction). Students were able to select one or more of theses to master a selected objective.

Several hypotheses were formulated with the expectation of results from the plot lending support to their validity and justification for use in subsequent investigations. First, it was hypothesized that individuals who participated would demonstrate a preference for instructional methodology, along with a resulting improvement in their statistical knowledge. Second, participants with low-visual spatial skills were predicted to benefit greater, by comparison, to those with high visual-spatial skills as measured by the Mental Rotation Test (developed by (Vandenberg & Kuse, 1978). Finally, it was hypothesized that the quality of interaction (animated vs. static) would be a factor in determining the extent to which participants would learn statistical concepts as measured by a twenty four question on screen measure.

First results

The purpose of this pilot study was to gather evidence which might support further investigation in the use of computers to teach statistics. It was not to establish statistical significance nor provide descriptive data for qualitative purpose per se. Consequently, analyses were not developed in depth. Whereas qualitative data was considered as more important, quantitative findings remained a secondary issue. Positive gains in knowledge were treated merely as indicators for continuation of this project. It might be interesting to note, however, that preliminary t-test to observe any knowledge gain were found with a significant t of 3.90, $p = .0023$.

Results of interviews conducted with participants provided useful information for the possible follow-up investigations. Comments on the text, graphic and static interaction (TGS) module were less enthusiastic than other presentations. It "...was not too different from reading a book" was a typical statement. The possibility of being distracted in the test situation sitting side

by side at computer terminals bother a few students who gave statements such as, it was "too easy for me to look at others and feel pressed." The text graphic, animated interaction (TGA) module held most of the participants captive with comments such as the following "help to see visually"; examples help me to process and better understand", and "why didn't you have something like this when I needed it?" These participants enabled the design functions to become seamless to the future participants. Their suggestions allowed the developers to stretch the capabilities of the design to accommodate more functions.

Second pilot

The next group of students were drawn to critique the statistical portion of the presentation. All these participants were drawn from graduate students (7 females and 5 males) enrolled in an Introductory research and statistic education class at Virginia Polytechnic Institute and State University. They were given an explanation of the purpose of this experiment as being related to computer-mediated learning. It was further explained that the subject of statistics was chosen as the content because of the difficulty perceived by graduate students who were required to complete a course in their programs of study.

The knowledge which was introduced to these group was material which they were required to understand for their classwork. This material covered three simple statistical concepts (Scales of Measurements, Central Tendency, and Scales of Variability). Subsequently, relevant content areas were introduced to participants in one of three different designs: text, graphics, plus static interactions (TGS); text, graphic, plus animated interaction (TGA); and text, graphics, plus audio(TGPA).

Participants in the TGS group were asked to read passages pertaining to content and manually move either forward of backwards throughout the program (one page at a time) until completing the exercise. At designated locations, participants were given the opportunity to further interact with the program by responding to several multiple choice questions designed to text comprehension. Questions were presented with participants responding via the click of a "mouse." Knowledge-of-response feedback was also generated by the computer.

Participants in the TGA group viewed the same text and graphics, and navigated through the program in an identical fashion to those students in the TGS group. However, the

interactions which tested comprehension were different in that they included an animated graphic visual component to visually reinforce their understanding of central limit theory concepts. That is, participants were asked to complete a table of points which were immediately plotted by the computer program. Repeated trails were optionally available, depending on the participant's perceived mastery of the concept.

Participants in the TGPA group passively listened to audio vignettes which included an actor reading aloud the same text and graphics presented on the screen in each of the previous groups. The computer automatically advanced the graphic display embedded in the program and thus altogether eliminated any control or interruption on the part of the user.

Results second pilot

Results of interviews conducted with the participants echoed the responses which were obtained by the first group such as: "not too much different from reading the book.."; "helps to see visually..". But new positive comments were received stating: "...good reinforcement for the traditional lecture..." and "... has great potential to assist understanding." Supporting Brunswik's thought of pacing were the comments regarding the student enjoyment of "reviewing at my own pace." A frequently occurring comment was that the participant chose to use multiple modules to visit content areas. "I preferred the audio, but using the text and graphic module allowed me to operate at my own pace." During the latest presentation the most popular module was the TGPA to which a participant commented that it "...allows me to see the graphics while listening to the voice." The option of choosing the method of presentations seemed pleasing to the respondents. "The ability to choose how one receives instruction would be very beneficial..." and being able to "...chose a preferred presentation is comfortable...," giving the user a "...sense of control."

Initial results from the various presentations have given external approval, adding to the project's developers own enthusiasm for future revision and testing. Some of these changes include: Altering the original "talking head" animation to more animation of the concepts. In other words additional color and movement of the concept were added to increase the ease of attention and retention and the addition of cues to indicate the end of the audio presentation. This will eliminate confusion over not knowing when the audio presentation for a particular

screen was over. The addition of alternative explanations will allow the student to have choice of repeating the first explanation or being presented the second or third explanation. In a classroom environment while teaching class an instructor has the opportunity to alter the first example if that example is not sufficient to express the concept to a student's understanding.

Further research questions include: How does the position of the text and graphic display affect the learner? What effect does the color and background have on the learner? Does freedom of movement allow the student to feel more in control of their learning? Additional revisions are planned for the screen design and quality of the presentation. The next phase of the development is to collect more quantitative information via computerized tools which will aid "on-line" assessment of learning styles, locus of control issues, and visuospatial skill levels. There is an expected correlation between these and other variables when compared to the level of learning associated with statistical concepts

Third pilot

Many (Alesandrini, 1987; Kobayashi, 1986; Rieber and Kini, 1991) have suggested that graphics added to textual instructional material will increase retention. Two questions were formed from these earlier suggestions: How much of the instructional material can be inferred from the graphics presentations? and, Can more instruction be inferred from animated versus static? A third stage investigated the inference without textual aids using 40 graduate students.

The introduction of the statistical concepts of ANOVA using CAI was examined to investigate and compare the effects of static and animated graphics. Demonstrations were used to lead the learner from concrete examples to abstract ideas by use of dynamically adjustable variables paired with immediate feedback. Principles of Boyles's and Charles laws governing the behavior of ideal gases were used to illustrate "main effects" and "interactions". The illustrated graphics were true to the scientific relationship between the variable(s) and the effect on a volume of gas contained with a piston. Students were randomly assigned to receive either static or animated graphics when appropriate throughout a series of encounters for the duration of the instruction. The student's first encounter was the graphics illustration (static or animated) changes in temperature have on the volume of a gas. In the second encounter pressure changes

were illustrated. The third encounter demonstrated the interactive effect simultaneous changes in both temperature and pressure with the resulting graphic illustrating the effect of their choices.

Results of third pilot

The purpose of this pilot study was to gather evidence which might support further investigation regarding the differences between using static and animated graphics in instructional setting. Although there was no significant difference between those who received static graphics versus the animated graphics, the scores for the static graphic participants were greater that those receiving animated instruction

Fourth Pilot

A fourth study duplicated the introduction of the statistical concepts of ANOVA using CAI was examined to investigate and compare the effects of static and animated graphics but added textual explanations to the graphic content.

Fourth Pilot results

There was no significant difference between the animated and static graphic presentations using 30 graduate students. The question remains of the comparison of static graphics versus animated graphics. Which is better?. Does it matter what the contextual material is to be delivered? For some of the material animated graphics seemed to aid recall whereas other material was aided by static graphics.

Fifth Pilot

Investigation of measuring individual differences was the next logical step. Can we use off-the-shelf cognitive measures (Locus of Control [LOC] and Field Independence) to project which type of presentation mode would be best to enable learners to recall instructional material? The fifth study duplicated the introduction of the statistical concepts of ANOVA using CAI instructing with text and static graphics or text and animated.

Fifth Pilot results

Seventy-five undergraduates participated and the results suggested that some advisement can be suggested with positive results for recall of new material. Levels of LOC seem to be able to suggest which presentational mode was best for the individual. This study suggested that a

LOC measure could be used for advisement with undergraduate students. Would it work for Graduate students?

Sixth Pilot

Before continuing to look at using cognitive based feedback to aid navigation through instructional material, a sixth study looked at freedom of navigation. The computer-assisted learning environment was created using a multimedia presentation program to deliver a text-only, text and static graphic, and text and animated graphic modes.

Sixth Pilot results

No significant differences in presentation mode were found among 50 graduate students who were allowed to freely navigate through the program. It was found that only 75% of available material was attended to during this study. This result presented the question on whether a forced attention to each informational segment would improve recall scores for the next stage.

Seventh Pilot

A group of 103 graduate students assigned to one of three presentation modes participated in a forced navigational pattern in order to ensure complete visitation to all instructional material. The same material which was developed for the sixth pilot was used in this study. The cognitive measures used in this study included: field-independence (Hidden Patterns, ETS); Holist/Serialist (Ford, 1985); Locus of Control (Rotter, 1966). And additional series of qualitative questions were added to the battery of test delivered by the program.

Seventh Pilot results

No differences in scores were found between the freedom of navigation and those who were forced to attend each screen. There was no clear distinct advantage to any cognitive measure for use of feedback for graduate students. However, in the caparison of presentation methods participants using the text-only mode performed significantly better on the recall test than their graphic counterparts. Many suggestions have surfaced through this series of investigation. Results were analyzed using ANCOVA and Aptitude-Treatment-Interaction (ATI) statistical procedures. The results demonstrate tendencies to justify further research using larger numbers of students studying research methodology and statistical analysis in post-secondary

settings. Student responses suggested that the program was enjoyable to use and would be used if it were available. Most students stated that they would prefer to have graphics included with the instruction

Conclusions

The development of a semester long course supplement and the assessment throughout the semester both on a short term as well as long term recall are the next step. It is only after an extended use that the term "novelty" will disappear. It will be only after the students are exposed for a semester will the statements "I was helped to process and better understand" and "I could review at my own pace" will have substantial meaning. Presently a full semester support of introduction to statistics is being created to be available for student remediation as well as aid students in clarifying instruction delivered in the classroom.

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